

**Table B.7 – Huffman codes for Layer III****Huffman code table for quadruples (A)**

vwx y	hlen	hcod
0000	1	1
0001	4	0101
0010	4	0100
0011	5	00101
0100	4	0110
0101	6	000101
0110	5	00100
0111	6	000100
1000	4	0111
1001	5	00011
1010	5	00110
1011	6	000000
1100	5	00111
1101	6	000010
1110	6	000011
1111	6	000001

**Huffman code table for quadruples (B)**

vwx y	hlen	hcod
0000	4	1111
0001	4	1110
0010	4	1101
0011	4	1100
0100	4	1011
0101	4	1010
0110	4	1001
0111	4	1000
1000	4	0111
1001	4	0110
1010	4	0101
1011	4	0100
1100	4	0011
1101	4	0010
1110	4	0001
1111	4	0000

**Huffman code table 0**

linbits=0

x	y	hlen
0	0	0

**Huffman code table 1**

linbits=0

x	y	hlen	hcod
0	0	1	1
0	1	3	001
1	0	2	01
1	1	3	000

**Huffman code table 2**

linbits=0

x	y	hlen	hcod
0	0	1	1
0	1	3	010
0	2	6	000001
1	0	3	011
1	1	3	001
1	2	5	00001
2	0	5	00011
2	1	5	00010
2	2	6	000000

**Huffman code table 3**

linbits=0

x	y	hlen	hcod
0	0	2	11
0	1	2	10
0	2	6	000001
1	0	3	001
1	1	2	01
1	2	5	00001
2	0	5	00011
2	1	5	00010
2	2	6	000000

**Huffman code table 4**

not used

**Huffman code table 5**

linbits=0

x	y	hlen	hcod
0	0	1	1
0	1	3	010
0	2	6	000110
0	3	7	0000101
1	0	3	011
1	1	3	001
1	2	6	000100
1	3	7	0000100
2	0	6	000111
2	1	6	000101
2	2	7	0000111
2	3	8	00000001
3	0	7	0000110
3	1	6	000001
3	2	7	0000001
3	3	8	00000000

**Huffman code table 6**

linbits=0

x	y	hlen	hcod
0	0	3	111
0	1	3	011
0	2	5	00101
0	3	7	0000001
1	0	3	110
1	1	2	10
1	2	4	0011
1	3	5	00010
2	0	4	0101
2	1	4	0100
2	2	5	00100
2	3	6	000001
3	0	6	000011
3	1	5	00011
3	2	6	000010
3	3	7	0000000

**Huffman code table 7**

linbits=0

x	y	hlen	hcod
0	0	1	1
0	1	3	010
0	2	6	001010
0	3	8	00010011
0	4	8	00010000
0	5	9	000001010
1	0	3	011
1	1	4	0011
1	2	6	000111
1	3	7	0001010
1	4	7	0000101
1	5	8	00000011
2	0	6	001011
2	1	5	00100
2	2	7	0001101
2	3	8	00010001
2	4	8	00001000
2	5	9	000000100
3	0	7	0001100
3	1	7	0001011
3	2	8	00010010
3	3	9	000001111
3	4	9	000001011
3	5	9	000000010
4	0	7	0000111
4	1	7	0000110
4	2	8	00001001
4	3	9	000001110
4	4	9	000000011
4	5	10	0000000001
5	0	8	00000110
5	1	8	00000100
5	2	9	000000101
5	3	10	0000000011
5	4	10	0000000010
5	5	10	0000000000

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Huffman code table 8

linbits=0

x	y	hlen	hcod
0	0	2	11
0	1	3	100
0	2	6	000110
0	3	8	00010010
0	4	8	00001100
0	5	9	000000101
1	0	3	101
1	1	2	01
1	2	4	0010
1	3	8	00010000
1	4	8	00001001
1	5	8	00000011
2	0	6	000111
2	1	4	0011
2	2	6	000101
2	3	8	00001110
2	4	8	00000111
2	5	9	000000011
3	0	8	00010011
3	1	8	00010001
3	2	8	00001111
3	3	9	000001101
3	4	9	000001010
3	5	10	0000000100
4	0	8	00001101
4	1	7	0000101
4	2	8	00001000
4	3	9	000001011
4	4	10	0000000101
4	5	10	0000000001
5	0	9	000001100
5	1	8	00000100
5	2	9	000000100
5	3	9	000000001
5	4	11	00000000001
5	5	11	00000000000

Huffman code table 9

linbits=0

x	y	hlen	hcod
0	0	3	111
0	1	3	101
0	2	5	01001
0	3	6	001110
0	4	8	00001111
0	5	9	000000111
1	0	3	110
1	1	3	100
1	2	4	0101
1	3	5	00101
1	4	6	000110
1	5	8	00000111
2	0	4	0111
2	1	4	0110
2	2	5	01000
2	3	6	001000
2	4	7	0001000
2	5	8	00000101
3	0	6	001111
3	1	5	00110
3	2	6	001001
3	3	7	0001010
3	4	7	0000101
3	5	8	00000001
4	0	7	0001011
4	1	6	000111
4	2	7	0001001
4	3	7	0000110
4	4	8	00000100
4	5	9	000000001
5	0	8	00001110
5	1	7	0000100
5	2	8	00000110
5	3	8	00000010
5	4	9	000000110
5	5	9	000000000

Huffman code table 10

linbits=0

x	y	hlen	hcod
0	0	1	1
0	1	3	010
0	2	6	001010
0	3	8	00010111
0	4	9	000100011
0	5	9	000011110
0	6	9	000001100
0	7	10	0000010001
1	0	3	011
1	1	4	0011
1	2	6	001000
1	3	7	0001100
1	4	8	00010010
1	5	9	000010101
1	6	8	00001100
1	7	8	00000111
2	0	6	001011
2	1	6	001001
2	2	7	0001111
2	3	8	00010101
2	4	9	000100000
2	5	10	0000101000
2	6	9	000010011
2	7	9	000000110
3	0	7	0001110
3	1	7	0001101
3	2	8	00010110
3	3	9	000100010
3	4	10	0000101110
3	5	10	0000010111
3	6	9	000010010
3	7	10	0000000111
4	0	8	00010100
4	1	8	00010011
4	2	9	000100001
4	3	10	0000101111
4	4	10	0000010110
4	5	10	0000010110
4	6	10	0000001001
4	7	10	0000000011
5	0	9	000011111
5	1	9	000010110
5	2	10	0000101001
5	3	10	0000011010
5	4	11	00000010101
5	5	11	00000010100
5	6	10	0000000101
5	7	11	00000000011
6	0	8	00001110
6	1	8	00001101
6	2	9	000001010
6	3	10	0000001011
6	4	10	0000010000
6	5	10	0000000110
6	6	11	00000000101
6	7	11	00000000001
7	0	9	000001001
7	1	8	00001000
7	2	9	000000111
7	3	10	0000001000
7	4	10	0000000100
7	5	11	00000000100
7	6	11	00000000010
7	7	11	00000000000

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Huffman code table 11

Huffman code table 12

Huffman code table 13

linbits=0

linbits=0

linbits=0

x	y	hlen	hcod
0	0	2	11
0	1	3	100
0	2	5	01010
0	3	7	0011000
0	4	8	00100010
0	5	9	000100001
0	6	8	00010101
0	7	9	000001111
1	0	3	101
1	1	3	011
1	2	4	0100
1	3	6	001010
1	4	8	00100000
1	5	8	00010001
1	6	7	0001011
1	7	8	00001010
2	0	5	01011
2	1	5	00111
2	2	6	001101
2	3	7	0010010
2	4	8	00011110
2	5	9	000011111
2	6	8	00010100
2	7	8	00000101
3	0	7	0011001
3	1	6	001011
3	2	7	0010011
3	3	9	000111011
3	4	8	00011011
3	5	10	0000010010
3	6	8	00001100
3	7	9	000000101
4	0	8	00100011
4	1	8	00100001
4	2	8	00011111
4	3	9	000111010
4	4	9	000011110
4	5	10	0000010000
4	6	9	000000111
4	7	10	0000000101
5	0	8	00011100
5	1	8	00011010
5	2	9	000100000
5	3	10	0000010011
5	4	10	0000010001
5	5	11	00000001111
5	6	10	0000001000
5	7	11	00000001110
6	0	8	00001110
6	1	7	0001100
6	2	7	0001001
6	3	8	00001101
6	4	9	000001110
6	5	10	0000001001
6	6	10	0000000100
6	7	10	0000000001
7	0	8	00001011
7	1	7	0000100
7	2	8	00000110
7	3	9	000000110
7	4	10	00000000110
7	5	10	0000000011
7	6	10	0000000010
7	7	10	0000000000

x	y	hlen	hcod
0	0	4	1001
0	1	3	110
0	2	5	10000
0	3	7	0100001
0	4	8	00101001
0	5	9	000100111
0	6	9	000100110
0	7	9	000011010
1	0	3	111
1	1	3	101
1	2	4	0110
1	3	5	01001
1	4	7	0010111
1	5	7	0010000
1	6	8	00011010
1	7	8	00001011
2	0	5	10001
2	1	4	0111
2	2	5	01011
2	3	6	001110
2	4	7	0010101
2	5	8	00011110
2	6	7	0001010
2	7	8	00000111
3	0	6	010001
3	1	5	01010
3	2	6	001111
3	3	6	001100
3	4	7	0010010
3	5	8	00011100
3	6	8	00001110
3	7	8	00000101
4	0	7	010000
4	1	6	001101
4	2	7	0010110
4	3	7	0010011
4	4	8	00010010
4	5	8	00010000
4	6	8	00001001
4	7	9	000000101
5	0	8	00101000
5	1	7	0010001
5	2	8	00011111
5	3	8	00011101
5	4	8	00010001
5	5	9	000001101
5	6	8	00000100
5	7	9	000000010
6	0	8	00011011
6	1	7	0001100
6	2	7	0001011
6	3	8	00001111
6	4	8	00001010
6	5	9	000000111
6	6	9	000000100
6	7	10	0000000001
7	0	9	000011011
7	1	8	00001100
7	2	8	00001000
7	3	9	000001100
7	4	9	000000110
7	5	9	000000011
7	6	9	000000001
7	7	10	0000000000

x	y	hlen	hcod
0	0	1	1
0	1	4	0101
0	2	6	001110
0	3	7	0010101
0	4	8	00100010
0	5	9	000110011
0	6	9	000101110
0	7	10	0001000111
0	8	9	000101010
0	9	10	0000110100
0	10	11	00001000100
0	11	11	00000110100
0	12	12	000001000011
0	13	12	000000101100
0	14	13	0000000101011
0	15	13	0000000010011
1	0	3	011
1	1	4	0100
1	2	6	001100
1	3	7	0010011
1	4	8	00011111
1	5	8	00011010
1	6	9	000101100
1	7	9	000100001
1	8	9	000011111
1	9	9	000011000
1	10	10	0000100000
1	11	10	0000011000
1	12	11	00000011111
1	13	12	000000100011
1	14	12	000000010110
1	15	12	000000001110
2	0	6	001111
2	1	6	001101
2	2	7	0010111
2	3	8	00100100
2	4	9	000111011
2	5	9	000110001
2	6	10	0001001101
2	7	10	0001000001
2	8	9	000011101
2	9	10	0000101000
2	10	10	0000011110
2	11	11	00000101000
2	12	11	00000011011
2	13	12	000000100001
2	14	13	0000000101010
2	15	13	0000000010000
3	0	7	0010110
3	1	7	0010100
3	2	8	00100101
3	3	9	000111101
3	4	9	000111000
3	5	10	0001001111
3	6	10	0001001001
3	7	10	0001000000
3	8	10	0000101011
3	9	11	00001001100
3	10	11	00000111000
3	11	11	00000100101
3	12	11	00000011010
3	13	12	000000011111
3	14	13	0000000011001
3	15	13	0000000001110
4	0	8	0010011
4	1	7	0010000
4	2	9	000111100
4	3	9	000111001
4	4	10	000110001
4	5	10	0001001011
4	6	11	000000011001
4	7	11	0000000011010
4	8	12	00000000011111
4	9	12	00000000010011
4	10	13	000000000011001
4	11	13	000000000001110
4	12	14	000000000000110
4	13	14	000000000000011
4	14	15	000000000000010
4	15	15	000000000000001

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4 7 11 00001011011
4 8 10 0000110110
4 9 11 00001001001
4 10 11 00000110111
4 11 12 000000101001
4 12 12 000000110000
4 13 13 0000000110101
4 14 13 0000000010111
4 15 14 00000000011000
5 0 9 000111010
5 1 8 00011011
5 2 9 000110010
5 3 10 0001100000
5 4 10 0001001100
5 5 10 0001000110
5 6 11 00001011101
5 7 11 00001010100
5 8 11 00001001101
5 9 11 00000111010
5 10 12 000001001111
5 11 11 00000011101
5 12 13 0000001001010
5 13 13 0000000110001
5 14 14 00000000101001
5 15 14 00000000010001
6 0 9 000101111
6 1 9 000101101
6 2 10 0001001110
6 3 10 0001001010
6 4 11 00001110011
6 5 11 00001011110
6 6 11 00001011010
6 7 11 00001001111
6 8 11 00001000101
6 9 12 000001010011
6 10 12 000001000111
6 11 12 000000110010
6 12 13 000000011011
6 13 13 0000000100110
6 14 14 00000000100100
6 15 14 0000000001111
7 0 10 0001001000
7 1 9 000100010
7 2 10 0000111000
7 3 11 00001011111
7 4 11 00001011100
7 5 11 00001010101
7 6 12 000001011011
7 7 12 000001011010
7 8 12 000001010110
7 9 12 000001001001
7 10 13 0000001001101
7 11 13 0000001000001
7 12 13 0000000110011
7 13 14 00000000101100
7 14 16 000000000101011
7 15 16 000000000101010
8 0 9 000101011
8 1 8 00010100
8 2 9 000011110
8 3 10 0000101100
8 4 10 0000110111
8 5 11 00001001110
8 6 11 00001001000
8 7 12 000001010111
8 8 12 000001001110
8 9 12 00000011101
8 10 12 000000101110
8 11 13 0000000110110
8 12 13 0000000100101
8 13 14 0000000011110
8 14 15 00000000010100
8 15 15 000000000010000
9 0 10 0000110101
9 1 9 000011001
9 2 10 0000101001
9 3 10 0000100101

```

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9 4 11 00000101100
9 5 11 00000111011
9 6 11 00000110110
9 7 13 0000001010001
9 8 12 000001000010
9 9 13 0000001001100
9 10 13 0000000111001
9 11 14 00000000110110
9 12 14 00000000100101
9 13 14 00000000010010
9 14 16 000000000100111
9 15 15 00000000001011
10 0 10 0000100011
10 1 10 0000100001
10 2 10 0000011111
10 3 11 00000111001
10 4 11 00000101010
10 5 12 000001010010
10 6 12 000001001000
10 7 13 0000001010000
10 8 12 000000101111
10 9 13 0000000111010
10 10 14 00000000110111
10 11 13 0000000010101
10 12 14 00000000010110
10 13 15 000000000011010
10 14 16 0000000000100110
10 15 17 0000000000010110
11 0 11 00000110101
11 1 10 0000011001
11 2 10 0000010111
11 3 11 00000100110
11 4 12 000001000110
11 5 12 000000111100
11 6 12 000000110011
11 7 12 000000100100
11 8 13 0000000110111
11 9 13 0000000011010
11 10 13 00000000100010
11 11 14 00000000010111
11 12 15 000000000011011
11 13 15 000000000001110
11 14 15 000000000001001
11 15 16 000000000000111
12 0 11 00000100010
12 1 11 00000100000
12 2 11 00000011100
12 3 12 000000100111
12 4 12 000000110001
12 5 13 0000001001011
12 6 12 000000011110
12 7 13 0000000110100
12 8 14 00000000110000
12 9 14 000000000101000
12 10 15 000000000110100
12 11 15 000000000011100
12 12 15 000000000010010
12 13 16 0000000000010001
12 14 16 0000000000001001
12 15 16 0000000000000101
13 0 12 000000101101
13 1 11 00000010101
13 2 12 000000100010
13 3 13 0000001000000
13 4 13 0000000111000
13 5 13 0000000110010
13 6 14 00000000110001
13 7 14 000000000101101
13 8 14 00000000011111
13 9 14 000000000010011
13 10 14 00000000001100
13 11 15 000000000001111
13 12 16 0000000000001010
13 13 15 000000000000111
13 14 16 0000000000000110
13 15 16 0000000000000011
14 0 13 0000000110000

```

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14 1 12 000000010111
14 2 12 000000010100
14 3 13 0000000100111
14 4 13 0000000100100
14 5 13 0000000100011
14 6 15 000000000110101
14 7 14 00000000010101
14 8 14 00000000010000
14 9 17 0000000000010111
14 10 15 000000000001101
14 11 15 000000000001010
14 12 15 000000000000110
14 13 17 0000000000000001
14 14 16 0000000000000100
14 15 16 0000000000000010
15 0 12 000000010000
15 1 12 000000001111
15 2 13 0000000010001
15 3 14 00000000011011
15 4 14 00000000011001
15 5 14 00000000010100
15 6 15 000000000011101
15 7 14 00000000001011
15 8 15 000000000010001
15 9 15 000000000001100
15 10 16 0000000000010000
15 11 16 0000000000001000
15 12 19 000000000000000001
15 13 18 000000000000000001
15 14 19 000000000000000000
15 15 16 0000000000000001

```

## Huffman code table 14

not used

## Huffman code table 15

linbits=0

x	y	hlen	hcod
0	0	3	111
0	1	4	1100
0	2	5	10010
0	3	7	0110101
0	4	7	0101111
0	5	8	01001100
0	6	9	001111100
0	7	9	001101100
0	8	9	001011001
0	9	10	0001111011
0	10	10	0001101100
0	11	11	00001110111
0	12	11	00001101011
0	13	11	00001010001
0	14	12	000001111010
0	15	13	0000000111111
1	0	4	1101
1	1	3	101
1	2	5	10000
1	3	6	011011
1	4	7	0101110
1	5	7	0100100
1	6	8	00111101
1	7	8	00110011
1	8	8	00101010
1	9	9	001000110
1	10	9	000110100
1	11	10	0001010011
1	12	10	0001000001
1	13	10	0000101001
1	14	11	00000111011
1	15	11	00000100100
2	0	5	10011

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2 1 5	10001	6 14 12	000001000110	11 11 11	00000011001
2 2 5	01111	6 15 12	000000011110	11 12 12	000000011101
2 3 6	011000	7 0 9	001101101	11 13 12	000000010010
2 4 7	0101001	7 1 8	00110101	11 14 12	000000001011
2 5 7	0100010	7 2 8	00110001	11 15 13	0000000001011
2 6 8	00111011	7 3 9	001011110	12 0 11	00001110110
2 7 8	00110000	7 4 9	001011000	12 1 10	0001000100
2 8 8	00101000	7 5 9	001001011	12 2 9	000011110
2 9 9	001000000	7 6 9	001000010	12 3 10	0000110111
2 10 9	000110010	7 7 10	0001111010	12 4 10	0000110010
2 11 10	0001001110	7 8 10	0001011011	12 5 10	0000101110
2 12 10	0000111110	7 9 10	0001001001	12 6 11	00001001010
2 13 11	00001010000	7 10 10	0000111000	12 7 11	00001000001
2 14 11	00000111000	7 11 10	0000101010	12 8 11	00000110001
2 15 11	00000100001	7 12 11	00001000000	12 9 11	00000100111
3 0 6	011101	7 13 11	00000101100	12 10 11	00000011000
3 1 6	011100	7 14 11	00000010101	12 11 11	00000010000
3 2 6	011001	7 15 12	000000011001	12 12 12	000000010110
3 3 7	0101011	8 0 9	001011010	12 13 12	000000001101
3 4 7	0100111	8 1 8	00101011	12 14 13	0000000001110
3 5 8	00111111	8 2 8	00101001	12 15 13	0000000000111
3 6 8	00110111	8 3 9	001001101	13 0 11	00001011011
3 7 9	001011101	8 4 9	001001001	13 1 10	0000101100
3 8 9	001001100	8 5 9	000111111	13 2 10	0000100111
3 9 9	000111011	8 6 9	000111000	13 3 10	0000100110
3 10 10	0001011101	8 7 10	0001011100	13 4 10	0000100010
3 11 10	0001001000	8 8 10	0001001101	13 5 11	00000111111
3 12 10	0000110110	8 9 10	0001000010	13 6 11	00000110100
3 13 11	00001001011	8 10 10	0000101111	13 7 11	00000101101
3 14 11	00000110010	8 11 11	00001000011	13 8 11	00000011111
3 15 11	00000011101	8 12 11	00000110000	13 9 12	000000110100
4 0 7	0110100	8 13 12	000000110101	13 10 12	000000011100
4 1 6	010110	8 14 12	000000100100	13 11 12	000000010011
4 2 7	0101010	8 15 12	000000010100	13 12 12	000000001110
4 3 7	0101000	9 0 9	001000111	13 13 12	000000001000
4 4 8	01000011	9 1 8	00100010	13 14 13	0000000001001
4 5 8	00111001	9 2 9	001000011	13 15 13	0000000000011
4 6 9	001011111	9 3 9	0001111100	14 0 12	000001111011
4 7 9	001001111	9 4 9	000111010	14 1 11	00000111100
4 8 9	001001000	9 5 9	000110001	14 2 11	00000111010
4 9 9	000111001	9 6 10	0001011000	14 3 11	00000110101
4 10 10	0001011001	9 7 10	0001001100	14 4 11	00000101111
4 11 10	0001000101	9 8 10	0001000011	14 5 11	00000101011
4 12 10	0000110001	9 9 11	00001101010	14 6 11	00000100000
4 13 11	00001000010	9 10 11	00001000111	14 7 11	00000010110
4 14 11	00000101110	9 11 11	00000110110	14 8 12	000000100101
4 15 11	00000011011	9 12 11	00000100110	14 9 12	000000011000
5 0 8	01001101	9 13 12	000000100111	14 10 12	000000010001
5 1 7	0100101	9 14 12	000000010111	14 11 12	000000001100
5 2 7	0100011	9 15 12	000000001111	14 12 13	0000000001111
5 3 8	01000010	10 0 10	0001101101	14 13 13	0000000001010
5 4 8	00111010	10 1 9	000110101	14 14 12	000000000010
5 5 8	00110100	10 2 9	000110011	14 15 13	0000000000001
5 6 9	001011011	10 3 9	000101111	15 0 12	000001000111
5 7 9	001001010	10 4 10	0001011010	15 1 11	00000100101
5 8 9	000111110	10 5 10	0001010010	15 2 11	00000100010
5 9 9	000110000	10 6 10	0000111010	15 3 11	00000011110
5 10 10	0001001111	10 7 10	0000111001	15 4 11	00000011100
5 11 10	0000111111	10 8 10	0000110000	15 5 11	00000010100
5 12 11	00001011010	10 9 11	00001001000	15 6 11	00000010001
5 13 11	00000111110	10 10 11	00000111001	15 7 12	000000011010
5 14 11	00000101000	10 11 11	00000101001	15 8 12	000000010101
5 15 12	000000100110	10 12 11	00000010111	15 9 12	000000010000
6 0 9	001111101	10 13 12	000000011011	15 10 12	000000001010
6 1 7	0100000	10 14 13	000000011110	15 11 12	000000000110
6 2 8	00111100	10 15 12	000000001001	15 12 13	0000000001000
6 3 8	00111000	11 0 10	0001010110	15 13 13	0000000000110
6 4 8	00110010	11 1 9	000101010	15 14 13	0000000000010
6 5 9	001011100	11 2 9	000101000	15 15 13	0000000000000
6 6 9	001001110	11 3 9	000100101		
6 7 9	001000001	11 4 10	0001000110		
6 8 9	000110111	11 5 10	0001000000		
6 9 10	0001010111	11 6 10	0000110100		
6 10 10	0001000111	11 7 10	0000101011		
6 11 10	0000110011	11 8 11	00001000110		
6 12 11	00001001001	11 9 11	00000110111		
6 13 11	00000110011	11 10 11	00000101010		

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## Huffman code table 16

linbits=1

x	y	hlen	hcod
0	0	1	1
0	1	4	0101
0	2	6	001110
0	3	8	00101100
0	4	9	001001010
0	5	9	00011111
0	6	10	0001101110
0	7	10	0001011101
0	8	11	00010101100
0	9	11	00010010101
0	10	11	00010001010
0	11	12	000011110010
0	12	12	000011100001
0	13	12	000011000011
0	14	13	0000101111000
0	15	9	000010001
1	0	3	011
1	1	4	0100
1	2	6	001100
1	3	7	0010100
1	4	8	00100011
1	5	9	000111110
1	6	9	000110101
1	7	9	000101111
1	8	10	0001010011
1	9	10	0001001011
1	10	10	0001000100
1	11	11	00001110111
1	12	12	000011001001
1	13	11	00001101011
1	14	12	000011001111
1	15	8	00001001
2	0	6	001111
2	1	6	001101
2	2	7	0010111
2	3	8	00100110
2	4	9	001000011
2	5	9	000111010
2	6	10	0001100111
2	7	10	0001011010
2	8	11	00010100001
2	9	10	0001001000
2	10	11	00001111111
2	11	11	00001110101
2	12	11	00001101110
2	13	12	000011010001
2	14	12	000011001110
2	15	9	000010000
3	0	8	00101101
3	1	7	0010101
3	2	8	00100111
3	3	9	001000101
3	4	9	001000000
3	5	10	0001110010
3	6	10	0001100011
3	7	10	0001010111
3	8	11	00010011110
3	9	11	00010001100
3	10	12	000011111100
3	11	12	000011010100
3	12	12	000011000111
3	13	13	0000110000011
3	14	13	0000101101101
3	15	10	0000011010
4	0	9	001001011
4	1	8	00100100
4	2	9	001000100
4	3	9	001000001
4	4	10	0001110011
4	5	10	0001100101
4	6	11	00010110011

4	7	11	00010100100
4	8	11	00010011011
4	9	12	000100001000
4	10	12	000011110110
4	11	12	000011100010
4	12	13	0000110001011
4	13	13	0000101111110
4	14	13	0000101101010
4	15	9	000001001
5	0	9	001000010
5	1	8	00011110
5	2	9	000111011
5	3	9	000111000
5	4	10	0001100110
5	5	11	00010111001
5	6	11	00010101101
5	7	12	000100001001
5	8	11	00010001110
5	9	12	000011111101
5	10	12	000011101000
5	11	13	0000110010000
5	12	13	0000110000100
5	13	13	0000101111010
5	14	14	00000110111101
5	15	10	0000010000
6	0	10	0001101111
6	1	9	000110110
6	2	9	000110100
6	3	10	0001100100
6	4	11	00010111000
6	5	11	00010110010
6	6	11	00010100000
6	7	11	00010000101
6	8	12	000100000001
6	9	12	000011110100
6	10	12	000011100100
6	11	12	000011011001
6	12	13	0000110000001
6	13	13	0000101101110
6	14	14	00001011001011
6	15	10	0000001010
7	0	10	0001100010
7	1	9	000110000
7	2	10	0001011011
7	3	10	0001011000
7	4	11	00010100101
7	5	11	00010011101
7	6	11	00010010100
7	7	12	000100000101
7	8	12	000011111000
7	9	13	0000110010111
7	10	13	0000110001101
7	11	13	0000101110100
7	12	13	0000101111100
7	13	15	000001101111001
7	14	15	000001101110100
7	15	10	0000001000
8	0	10	0001010101
8	1	10	0001010100
8	2	10	0001010001
8	3	11	00010011111
8	4	11	00010011100
8	5	11	00010001111
8	6	12	000100000100
8	7	12	000011111001
8	8	13	0000110101011
8	9	13	0000110010001
8	10	13	0000110001000
8	11	13	0000101111111
8	12	14	00001011010111
8	13	14	00001011001001
8	14	14	00001011000100
8	15	10	0000000111
9	0	11	00010011010
9	1	10	0001001100
9	2	10	0001001001
9	3	11	00010001101
9	4	11	00010000011
9	5	12	00010000000
9	6	12	000100000000
9	7	13	0001000000010
9	8	13	0001000000000
9	9	13	00010000000000
9	10	13	000100000000000
9	11	13	0001000000000000
9	12	13	00010000000000000
9	13	13	000100000000000000
9	14	13	0001000000000000000
9	15	13	00010000000000000000

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14	1	13	0000101110001
14	2	11	00001100110
14	3	12	000010111011
14	4	14	00001011010110
14	5	14	00001011010010
14	6	13	0000101100110
14	7	14	00001011000111
14	8	14	00001011000101
14	9	15	000001101100010
14	10	16	0000011011000110
14	11	15	000001101100111
14	12	17	00000110110000010
14	13	15	000001101100110
14	14	14	00000110110010
14	15	11	00000000000
15	0	9	000001100
15	1	8	00001010
15	2	8	00000111
15	3	9	000001011
15	4	9	000001010
15	5	10	0000010001
15	6	10	0000001011
15	7	10	0000001001
15	8	11	00000001101
15	9	11	00000001100
15	10	11	00000001010
15	11	11	00000000111
15	12	11	00000000101
15	13	11	00000000011
15	14	11	00000000001
15	15	8	00000011

**Huffman code table 17**

same as table 16, but linbits=2

**Huffman code table 18**

same as table 16, but linbits=3

**Huffman code table 19**

same as table 16, but linbits=4

**Huffman code table 20**

same as table 16, but linbits=6

**Huffman code table 21**

same as table 16, but linbits=8

**Huffman code table 22**

same as table 16, but linbits=10

**Huffman code table 23**

same as table 16, but linbits=13

**Huffman code table 24**

linbits=4

x	y	hlen	hcod
0	0	4	1111
0	1	4	1101
0	2	6	101110
0	3	7	1010000
0	4	8	10010010
0	5	9	100000110
0	6	9	011111000
0	7	10	0110110010
0	8	10	0110101010
0	9	11	01010011101
0	10	11	01010001101
0	11	11	01010001001
0	12	11	01001101101
0	13	11	01000000101
0	14	12	010000001000
0	15	9	001011000
1	0	4	1110
1	1	4	1100
1	2	5	10101
1	3	6	100110
1	4	7	1000111
1	5	8	10000010
1	6	8	01111010
1	7	9	011011000
1	8	9	011010001
1	9	9	011000110
1	10	10	0101000111
1	11	10	0101011001
1	12	10	0100111111
1	13	10	0100101001
1	14	10	0100010111
1	15	8	00101010
2	0	6	101111
2	1	5	10110
2	2	6	101001
2	3	7	1001010
2	4	7	1000100
2	5	8	10000000
2	6	8	01111000
2	7	9	011011101
2	8	9	011001111
2	9	9	011000010
2	10	9	010110110
2	11	10	0101010100
2	12	10	0100111011
2	13	10	0100100111
2	14	11	01000011101
2	15	7	0010010
3	0	7	1010001
3	1	6	100111
3	2	7	1001011
3	3	7	1000110
3	4	8	10000110
3	5	8	01111101
3	6	8	01110100
3	7	9	011011100
3	8	9	011001100
3	9	9	010111110
3	10	9	010110010
3	11	10	0101000101
3	12	10	0100110111
3	13	10	0100100101
3	14	10	0100001111
3	15	7	0010000
4	0	8	10010011
4	1	7	1001000
4	2	7	1000101
4	3	8	10000111
4	4	8	01111111
4	5	8	01110110
4	6	8	01110000

4	7	9	011010010
4	8	9	011001000
4	9	9	010111100
4	10	10	0101100000
4	11	10	0101000011
4	12	10	0100110010
4	13	10	0100011101
4	14	11	01000011100
4	15	7	0001110
5	0	9	100000111
5	1	7	1000010
5	2	8	10000001
5	3	8	01111110
5	4	8	01110111
5	5	8	01110010
5	6	9	011010110
5	7	9	011001010
5	8	9	011000000
5	9	9	010110100
5	10	10	0101010101
5	11	10	0100111101
5	12	10	0100101101
5	13	10	0100011001
5	14	10	0100000110
5	15	7	0001100
6	0	9	011111001
6	1	8	01111011
6	2	8	01111001
6	3	8	01110101
6	4	8	01110001
6	5	9	011010111
6	6	9	011001110
6	7	9	011000011
6	8	9	010111001
6	9	10	0101011011
6	10	10	0101001010
6	11	10	0100110100
6	12	10	0100100011
6	13	10	0100010000
6	14	11	01000001000
6	15	7	0001010
7	0	10	0110110011
7	1	8	01110011
7	2	8	01101111
7	3	8	01101101
7	4	9	011010011
7	5	9	011001011
7	6	9	011000100
7	7	9	010111011
7	8	10	0101100001
7	9	10	0101001100
7	10	10	0100111001
7	11	10	0100101010
7	12	10	0100011011
7	13	11	01000010011
7	14	11	00101111101
7	15	8	00010001
8	0	10	0110101011
8	1	9	011010100
8	2	9	011010000
8	3	9	011001101
8	4	9	011001001
8	5	9	011000001
8	6	9	010111010
8	7	9	010110001
8	8	9	010101001
8	9	10	0101000000
8	10	10	0100101111
8	11	10	0100011110
8	12	10	0100000100
8	13	11	01000000010
8	14	11	00101111001
8	15	8	00010000
9	0	10	0101001111
9	1	9	011000111
9	2	9	011000101
9	3	9	010111111

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9	4	9	010111101
9	5	9	010110101
9	6	9	010101110
9	7	10	0101001101
9	8	10	0101000001
9	9	10	0100110001
9	10	10	0100100001
9	11	10	0100010011
9	12	11	01000001001
9	13	11	00101111011
9	14	11	00101110011
9	15	8	00001011
10	0	11	01010011100
10	1	9	010111000
10	2	9	010110111
10	3	9	010110011
10	4	9	010101111
10	5	10	0101011000
10	6	10	0101001011
10	7	10	0100111010
10	8	10	0100110000
10	9	10	0100100010
10	10	10	0100010101
10	11	11	01000010010
10	12	11	00101111111
10	13	11	00101110101
10	14	11	00101101110
10	15	8	00001010
11	0	11	01010001100
11	1	10	0101011010
11	2	9	010101011
11	3	9	010101000
11	4	9	010100100
11	5	10	0100111110
11	6	10	0100110101
11	7	10	0100101011
11	8	10	0100011111
11	9	10	0100010100
11	10	10	0100000111
11	11	11	01000000001
11	12	11	00101110111
11	13	11	00101110000
11	14	11	00101101010
11	15	8	00000110
12	0	11	01010001000
12	1	10	0101000010
12	2	10	0100111100
12	3	10	0100111000
12	4	10	0100110011
12	5	10	0100101110
12	6	10	0100100100
12	7	10	0100011100
12	8	10	0100001101
12	9	10	0100000101
12	10	11	01000000000
12	11	11	00101111000
12	12	11	00101110010
12	13	11	00101101100
12	14	11	00101100111
12	15	8	00000100
13	0	11	01001101100
13	1	10	0100101100
13	2	10	0100101000
13	3	10	0100100110
13	4	10	0100100000
13	5	10	0100011010
13	6	10	0100010001
13	7	10	0100001010
13	8	11	01000000011
13	9	11	00101111100
13	10	11	00101110110
13	11	11	00101110001
13	12	11	00101101101
13	13	11	00101101001
13	14	11	00101100101
13	15	8	00000010
14	0	12	010000001001

14	1	10	0100011000
14	2	10	0100010110
14	3	10	0100010010
14	4	10	0100001011
14	5	10	0100001000
14	6	10	0100000011
14	7	11	00101111110
14	8	11	00101111010
14	9	11	00101110100
14	10	11	00101101111
14	11	11	00101101011
14	12	11	00101101000
14	13	11	00101100110
14	14	11	00101100100
14	15	8	00000000
15	0	8	00101011
15	1	7	0010100
15	2	7	0010011
15	3	7	0010001
15	4	7	0001111
15	5	7	0001101
15	6	7	0001011
15	7	7	0001001
15	8	7	0000111
15	9	7	0000110
15	10	7	0000100
15	11	8	00000111
15	12	8	00000101
15	13	8	00000011
15	14	8	00000001
15	15	4	0011

**Huffman code table 25**

same as table 24, but linbits=5

**Huffman code table 26**

same as table 24, but linbits=6

**Huffman code table 27**

same as table 24, but linbits=7

**Huffman code table 28**

same as table 24, but linbits=8

**Huffman code table 29**

same as table 24, but linbits=9

**Huffman code table 30**

same as table 24, but linbits=11

**Huffman code table 31**

same as table 24, but linbits=13

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**Table B.8 – Layer III scalefactor bands**

These tables list the width of each scalefactor band. There are 21 bands at each sampling frequency for long (type 0,1 or 3) windows and 12 bands each for short windows.

**Table B.8a. -- 32kHz sampling rate****long blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	4	16	19
5	4	20	23
6	6	24	29
7	6	30	35
8	8	36	43
9	10	44	53
10	12	54	65
11	16	66	81
12	20	82	101
13	24	102	125
14	30	126	155
15	38	156	193
16	46	194	239
17	56	240	295
18	68	296	363
19	84	364	447
20	102	448	549

**short blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	6	16	21
5	8	22	29
6	12	30	41
7	16	42	57
8	20	58	77
9	26	78	103
10	34	104	137
11	42	138	179

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**Table B.8b. -- 44,1kHz sampling rate****long blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	4	16	19
5	4	20	23
6	6	24	29
7	6	30	35
8	8	36	43
9	8	44	51
10	10	52	61
11	12	62	73
12	16	74	89
13	20	90	109
14	24	110	133
15	28	134	161
16	34	162	195
17	42	196	237
18	50	238	287
19	54	288	341
20	76	342	417

**short blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	6	16	21
5	8	22	29
6	10	30	39
7	12	40	51
8	14	52	65
9	18	66	83
10	22	84	105
11	30	106	135

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**Table B.8c. -- 48 kHz sampling rate****long blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	4	16	19
5	4	20	23
6	6	24	29
7	6	30	35
8	6	36	41
9	8	42	49
10	10	50	59
11	12	60	71
12	16	72	87
13	18	88	105
14	22	106	127
15	28	128	155
16	34	156	189
17	40	190	229
18	46	230	275
19	54	276	329
20	54	330	383

**short blocks:**

scale factor band	width of band	index of start	index of end
0	4	0	3
1	4	4	7
2	4	8	11
3	4	12	15
4	6	16	21
5	6	22	27
6	10	28	37
7	12	38	49
8	14	50	63
9	16	64	79
10	20	80	99
11	26	100	125

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**Table B.9 -- Layer III coefficients for aliasing reduction:**

(i)	$c_i$
0	-0,6
1	-0,535
2	-0,33
3	-0,185
4	-0,095
5	-0,041
6	-0,0142
7	-0,0037

The butterfly coefficients  $cs_i$  and  $ca_i$  are calculated as follows:

$$cs_i = \frac{1}{\sqrt{1 + c_i^2}}, \quad ca_i = \frac{c_i}{\sqrt{1 + c_i^2}}$$

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## Annex C

(informative)

### The encoding process

#### C.1 Encoder

##### C.1.1 Overview

For each of the layers, an example of one suitable encoder with the corresponding flow-diagram is given in this annex. In subsequent clauses the analysis subband filter and the layer-specific encoding techniques are described. In annex D two examples of psychoacoustic models, which are common to all layers, are described. A short introduction describes the overall philosophy.

##### C.1.1.1 Introduction

The ISO/IEC 11172-3 (MPEG-Audio) algorithm is a psychoacoustic algorithm. The figure C.1 shows the primary parts of a psychoacoustic algorithm.

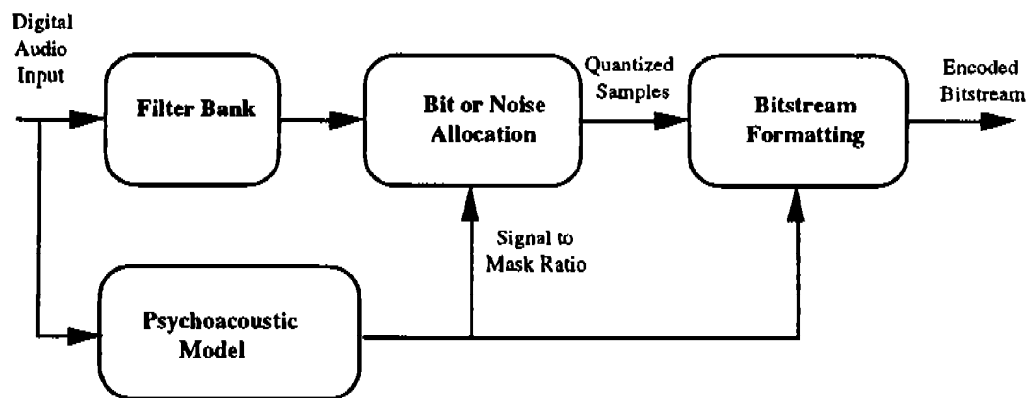


Figure C.1 -- ISO/IEC 11172-3 (MPEG-audio) encoder block diagram

The four primary parts of the psychoacoustic encoder are:

##### C.1.1.1.1 The filterbank

The filterbank does a time to frequency mapping. There are two filterbanks used in the ISO/IEC 11172-3 (MPEG-Audio) algorithm, a polyphase filterbank and a hybrid polyphase/MDCT filterbank. Each provides a specific mapping in time and frequency. These filterbanks are critically sampled (i.e. there are as many samples in the analyzed domain as there are in the time domain). These filterbanks provide the primary frequency separation for the encoder, and the reconstruction filters for the decoder. The output samples of the filterbank are quantized.

##### C.1.1.1.2 The psychoacoustic model

The psychoacoustic model calculates a just noticeable noise-level for each band in the filterbank. This noise level is used in the bit or noise allocation to determine the actual quantizers and quantizer levels. There are two psychoacoustic models presented in annex D. While they can both be applied to any layer of the ISO/IEC 11172-3 (MPEG-Audio) algorithm, in practice Model 1 has been used for Layers I and II, and Model 2 for Layer III. In both psychoacoustic models, the final output of the model is a signal-to-mask ratio (SMR) for each band (Layers I and II) or group of bands (Layer III).

**C.1.1.1.3 Bit or noise Allocation**

The allocator looks at both the output samples from the filterbank and the SMR's from the psychoacoustic model, and adjusts the bit allocation (Layers I and II) or noise allocation (Layer III) in order simultaneously to meet both the bitrate requirements and the masking requirements. At low bitrates, these methods attempt to spend bits in a fashion that is psychoacoustically inoffensive when they cannot meet the psychoacoustic demand at the required bitrate.

**C.1.1.1.4 The bitstream formatter**

The bitstream formatter takes the quantized filterbank outputs, together with the bit allocation (Layers I and II) or noise allocation (Layer III) and other required side information, and encodes and formats that information in an efficient fashion. In the case of Layer III, the Huffman codes are also inserted at this point.

**C.1.1.2 The filterbank**

In Layers I and II, a filterbank with 32 subbands is used. In each subband, 12 or 36 samples are grouped for processing. In Layer III, the filterbank has a signal-dependent resolution, where there are either 6x32 or 18x32 frequency bands. In the case where there are 6x32 frequency samples, the 3 sets of each frequency are quantized separately.

**C.1.1.3 Bit or noise allocation method**

There are two different bitrate control methods explained in this annex. In Layers I and II this method is a bit allocation process, i.e. a number of bits is assigned to each sample (or group of samples) in each subband. The method for Layer III is a noise-allocation loop, where the quantizers are varied in an organized fashion, and the variable to be controlled is actually the injected noise. In either case, the result is a set of quantization parameters and quantized output samples that are given to the bitstream formatter.

**C.1.1.4 Bitstream formatting**

The bitstream formatter varies from layer to layer. In Layers I and II, a fixed PCM code is used for each subband sample, with the exception that in Layer II quantized samples may be grouped. In Layer III, Huffman codes are used to represent the quantized frequency samples. These Huffman codes are variable-length codes that allow for more efficient bitstream representation of the quantized samples at the cost of additional complexity.

**C.1.2 Input high-pass filter**

The encoding algorithms provide a frequency response down to d.c. However, in applications where this is not a requirement, it is recommended that a high-pass filter be included at the input of the encoder. The cut-off frequency should be in the range of 2 to 10 Hz.

The application of such a high-pass filter avoids an unnecessarily high bitrate requirement for the lowest subband and increases the overall audio quality.

**C.1.3 Analysis subband filter**

An analysis subband filterbank is used to split the broadband signal with sampling frequency  $f_s$  into 32 equally spaced subbands with sampling frequencies  $f_s/32$ . The flow chart of this process with the appropriate formulas is given in figure C.4 "Analysis Subband Filter Flow Chart". The analysis subband filtering includes the following steps:

- Input 32 audio samples.
- Build an input sample vector  $X$  of 512 elements. The 32 audio samples are shifted in at positions 0 to 31, the most recent one at position 0, and the 32 oldest elements are shifted out.
- Window vector  $X$  by vector  $C$ . The coefficients are to be found in table C.1.
- Calculate the 64 values  $Y_i$  according to the formula given in the flow chart.
- Calculate the 32 subband samples  $S_i$  by matrixing. The coefficients for the matrix can be calculated by the following formula:

$$M_{ik} = \cos [(2i + 1)(k - 16)\pi/64], \quad \text{for } i = 0 \text{ to } 31, \text{ and } k = 0 \text{ to } 63.$$

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Table C.1 -- Coefficients  $C_i$  of the Analysis Window

C[ 0]= 0,000000000	C[ 1]=-0,000000477	C[ 2]=-0,000000477	C[ 3]=-0,000000477
C[ 4]=-0,000000477	C[ 5]=-0,000000477	C[ 6]=-0,000000477	C[ 7]=-0,000000954
C[ 8]=-0,000000954	C[ 9]=-0,000000954	C[10]=-0,000000954	C[11]=-0,000001431
C[12]=-0,000001431	C[13]=-0,000001907	C[14]=-0,000001907	C[15]=-0,000002384
C[16]=-0,000002384	C[17]=-0,000002861	C[18]=-0,000003338	C[19]=-0,000003338
C[20]=-0,000003815	C[21]=-0,000004292	C[22]=-0,000004768	C[23]=-0,000005245
C[24]=-0,000006199	C[25]=-0,000006676	C[26]=-0,000007629	C[27]=-0,000008106
C[28]=-0,000009060	C[29]=-0,000010014	C[30]=-0,000011444	C[31]=-0,000012398
C[32]=-0,000013828	C[33]=-0,000014782	C[34]=-0,000016689	C[35]=-0,000018120
C[36]=-0,000019550	C[37]=-0,000021458	C[38]=-0,000023365	C[39]=-0,000025272
C[40]=-0,000027657	C[41]=-0,000030041	C[42]=-0,000032425	C[43]=-0,000034809
C[44]=-0,000037670	C[45]=-0,000040531	C[46]=-0,000043392	C[47]=-0,000046253
C[48]=-0,000049591	C[49]=-0,000052929	C[50]=-0,000055790	C[51]=-0,000059605
C[52]=-0,000062943	C[53]=-0,000066280	C[54]=-0,000070095	C[55]=-0,000073433
C[56]=-0,000076771	C[57]=-0,000080585	C[58]=-0,000083923	C[59]=-0,000087261
C[60]=-0,000090599	C[61]=-0,000093460	C[62]=-0,000096321	C[63]=-0,000099182
C[64]= 0,000101566	C[65]= 0,000103951	C[66]= 0,000105858	C[67]= 0,000107288
C[68]= 0,000108242	C[69]= 0,000108719	C[70]= 0,000108719	C[71]= 0,000108242
C[72]= 0,000106812	C[73]= 0,000105381	C[74]= 0,000102520	C[75]= 0,000099182
C[76]= 0,000095367	C[77]= 0,000090122	C[78]= 0,000084400	C[79]= 0,000077724
C[80]= 0,000069618	C[81]= 0,000060558	C[82]= 0,000050545	C[83]= 0,000039577
C[84]= 0,000027180	C[85]= 0,000013828	C[86]=-0,000000954	C[87]=-0,000017166
C[88]=-0,000034332	C[89]=-0,000052929	C[90]=-0,000072956	C[91]=-0,000093937
C[92]=-0,000116348	C[93]=-0,000140190	C[94]=-0,000165462	C[95]=-0,000191212
C[96]=-0,000218868	C[97]=-0,000247478	C[98]=-0,000277042	C[99]=-0,000307560
C[100]=-0,000339031	C[101]=-0,000371456	C[102]=-0,000404358	C[103]=-0,000438213
C[104]=-0,000472546	C[105]=-0,000507355	C[106]=-0,000542164	C[107]=-0,000576973
C[108]=-0,000611782	C[109]=-0,000646591	C[110]=-0,000680923	C[111]=-0,000714302
C[112]=-0,000747204	C[113]=-0,000779152	C[114]=-0,000809669	C[115]=-0,000838757
C[116]=-0,000866413	C[117]=-0,000891685	C[118]=-0,000915051	C[119]=-0,000935555
C[120]=-0,000954151	C[121]=-0,000968933	C[122]=-0,000980854	C[123]=-0,000989437
C[124]=-0,000994205	C[125]=-0,000995159	C[126]=-0,000991821	C[127]=-0,000983715
C[128]= 0,000971317	C[129]= 0,000953674	C[130]= 0,000930786	C[131]= 0,000902653
C[132]= 0,000868797	C[133]= 0,000829220	C[134]= 0,000783920	C[135]= 0,000731945
C[136]= 0,000674248	C[137]= 0,000610352	C[138]= 0,000539303	C[139]= 0,000462532
C[140]= 0,000378609	C[141]= 0,000288486	C[142]= 0,000191689	C[143]= 0,000088215
C[144]=-0,000021458	C[145]=-0,000137329	C[146]=-0,000259876	C[147]=-0,000388145
C[148]=-0,000522137	C[149]=-0,000661850	C[150]=-0,000806808	C[151]=-0,000956535
C[152]=-0,001111031	C[153]=-0,001269817	C[154]=-0,001432419	C[155]=-0,001597881
C[156]=-0,001766682	C[157]=-0,001937389	C[158]=-0,002110004	C[159]=-0,002283096
C[160]= 0,002457142	C[161]=-0,002630711	C[162]=-0,002803326	C[163]=-0,002974033
C[164]=-0,003141880	C[165]=-0,003306866	C[166]=-0,003467083	C[167]=-0,003622532
C[168]=-0,003771782	C[169]=-0,003914356	C[170]=-0,004048824	C[171]=-0,004174709
C[172]=-0,004290581	C[173]=-0,004395962	C[174]=-0,004489899	C[175]=-0,004570484
C[176]=-0,004638195	C[177]=-0,004691124	C[178]=-0,004728317	C[179]=-0,004748821
C[180]=-0,004752159	C[181]=-0,004737377	C[182]=-0,004703045	C[183]=-0,004649162
C[184]=-0,004573822	C[185]=-0,004477024	C[186]=-0,004357815	C[187]=-0,004215240
C[188]=-0,004049301	C[189]=-0,003858566	C[190]=-0,003643036	C[191]=-0,003401756
C[192]= 0,003134727	C[193]= 0,002841473	C[194]= 0,002521515	C[195]= 0,002174854
C[196]= 0,001800537	C[197]= 0,001399517	C[198]= 0,000971317	C[199]= 0,000515938
C[200]= 0,000033379	C[201]=-0,000475883	C[202]=-0,001011848	C[203]=-0,001573563
C[204]=-0,002161503	C[205]=-0,002774239	C[206]=-0,003411293	C[207]=-0,004072189
C[208]=-0,004756451	C[209]=-0,005462170	C[210]=-0,006189346	C[211]=-0,006937027
C[212]=-0,007703304	C[213]=-0,008487225	C[214]=-0,009287834	C[215]=-0,010103703
C[216]=-0,010933399	C[217]=-0,011775017	C[218]=-0,012627602	C[219]=-0,013489246
C[220]=-0,014358521	C[221]=-0,015233517	C[222]=-0,016112804	C[223]=-0,016994476
C[224]=-0,017876148	C[225]=-0,018756866	C[226]=-0,019634247	C[227]=-0,020506059
C[228]=-0,021372318	C[229]=-0,022228718	C[230]=-0,023074150	C[231]=-0,023907185
C[232]=-0,024725437	C[233]=-0,025527000	C[234]=-0,026310921	C[235]=-0,027073860
C[236]=-0,027815342	C[237]=-0,028532982	C[238]=-0,029224873	C[239]=-0,029890060
C[240]=-0,030526638	C[241]=-0,031132698	C[242]=-0,031706810	C[243]=-0,032248020
C[244]=-0,032754898	C[245]=-0,033225536	C[246]=-0,033659935	C[247]=-0,034055710
C[248]=-0,034412861	C[249]=-0,034730434	C[250]=-0,035007000	C[251]=-0,035242081
C[252]=-0,035435200	C[253]=-0,035586357	C[254]=-0,035694122	C[255]= 0,035758972
C[256]= 0,035780907	C[257]= 0,035758972	C[258]= 0,035694122	C[259]= 0,035586357
C[260]= 0,035435200	C[261]= 0,035242081	C[262]= 0,035007000	C[263]= 0,034730434
C[264]= 0,034412861	C[265]= 0,034055710	C[266]= 0,033659935	C[267]= 0,033225536
C[268]= 0,032754898	C[269]= 0,032248020	C[270]= 0,031706810	C[271]= 0,031132698
C[272]= 0,030526638	C[273]= 0,029890060	C[274]= 0,029224873	C[275]= 0,028532982
C[276]= 0,027815342	C[277]= 0,027073860	C[278]= 0,026310921	C[279]= 0,025527000
C[280]= 0,024725437	C[281]= 0,023907185	C[282]= 0,023074150	C[283]= 0,022228718
C[284]= 0,021372318	C[285]= 0,020506859	C[286]= 0,019634247	C[287]= 0,018756866
C[288]= 0,017876148	C[289]= 0,016994476	C[290]= 0,016112804	C[291]= 0,015233517

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C[292]= 0,014358521	C[293]= 0,013489246	C[294]= 0,012627602	C[295]= 0,011775017
C[296]= 0,010933399	C[297]= 0,010103703	C[298]= 0,009287834	C[299]= 0,008487225
C[300]= 0,007703304	C[301]= 0,006937027	C[302]= 0,006189346	C[303]= 0,005462170
C[304]= 0,004756451	C[305]= 0,004072189	C[306]= 0,003411293	C[307]= 0,002774239
C[308]= 0,002161503	C[309]= 0,001573563	C[310]= 0,001011848	C[311]= 0,000475883
C[312]= -0,000033379	C[313]= -0,000515938	C[314]= -0,000971317	C[315]= -0,001399517
C[316]= -0,001800537	C[317]= -0,002174854	C[318]= -0,002521515	C[319]= -0,002841473
C[320]= 0,003134727	C[321]= 0,003401756	C[322]= 0,003643036	C[323]= 0,003858566
C[324]= 0,004049301	C[325]= 0,004215240	C[326]= 0,004357815	C[327]= 0,004477024
C[328]= 0,004573822	C[329]= 0,004649162	C[330]= 0,004703045	C[331]= 0,004737377
C[332]= 0,004752159	C[333]= 0,004748821	C[334]= 0,004728317	C[335]= 0,004691124
C[336]= 0,004638195	C[337]= 0,004570484	C[338]= 0,004489899	C[339]= 0,004395962
C[340]= 0,004290581	C[341]= 0,004174709	C[342]= 0,004048824	C[343]= 0,003914356
C[344]= 0,003771782	C[345]= 0,003622532	C[346]= 0,003467083	C[347]= 0,003306866
C[348]= 0,003141880	C[349]= 0,002974033	C[350]= 0,002803326	C[351]= 0,002630711
C[352]= 0,002457142	C[353]= 0,002283096	C[354]= 0,002110004	C[355]= 0,001937389
C[356]= 0,001766682	C[357]= 0,001597881	C[358]= 0,001432419	C[359]= 0,001269817
C[360]= 0,001111031	C[361]= 0,000956535	C[362]= 0,000806808	C[363]= 0,000661850
C[364]= 0,000522137	C[365]= 0,000388145	C[366]= 0,000259876	C[367]= 0,000137329
C[368]= 0,000068797	C[369]= -0,000088215	C[370]= -0,000191689	C[371]= -0,000288486
C[372]= -0,000378609	C[373]= -0,000462532	C[374]= -0,000539303	C[375]= -0,000610352
C[376]= -0,000674248	C[377]= -0,000731945	C[378]= -0,000783920	C[379]= -0,000829220
C[380]= -0,000868797	C[381]= -0,000902653	C[382]= -0,000930786	C[383]= -0,000953674
C[384]= 0,000971317	C[385]= 0,000983715	C[386]= 0,000991821	C[387]= 0,000995159
C[388]= 0,000994205	C[389]= 0,000989437	C[390]= 0,000980854	C[391]= 0,000968933
C[392]= 0,000954151	C[393]= 0,000935555	C[394]= 0,000915051	C[395]= 0,000891685
C[396]= 0,000866413	C[397]= 0,000838757	C[398]= 0,000809669	C[399]= 0,000779152
C[400]= 0,000747204	C[401]= 0,000714302	C[402]= 0,000680923	C[403]= 0,000646591
C[404]= 0,000611782	C[405]= 0,000576973	C[406]= 0,000542164	C[407]= 0,000507355
C[408]= 0,000472546	C[409]= 0,000438213	C[410]= 0,000404358	C[411]= 0,000371456
C[412]= 0,000339031	C[413]= 0,000307560	C[414]= 0,000277042	C[415]= 0,000247478
C[416]= 0,000218868	C[417]= 0,000191212	C[418]= 0,000165462	C[419]= 0,000140190
C[420]= 0,000116348	C[421]= 0,000093937	C[422]= 0,000072956	C[423]= 0,000052929
C[424]= 0,000034332	C[425]= 0,000017166	C[426]= 0,000000954	C[427]= -0,000013828
C[428]= -0,000027180	C[429]= -0,000039577	C[430]= -0,000050545	C[431]= -0,000060558
C[432]= -0,000069618	C[433]= -0,000077724	C[434]= -0,000084400	C[435]= -0,000090122
C[436]= -0,000095367	C[437]= -0,000099182	C[438]= -0,000102520	C[439]= -0,000105381
C[440]= -0,000106812	C[441]= -0,000108242	C[442]= -0,000108719	C[443]= -0,000108719
C[444]= -0,000108242	C[445]= -0,000107288	C[446]= -0,000105858	C[447]= -0,000103951
C[448]= 0,000101566	C[449]= 0,000099182	C[450]= 0,000096321	C[451]= 0,000093460
C[452]= 0,000090599	C[453]= 0,000087261	C[454]= 0,000083923	C[455]= 0,000080585
C[456]= 0,000076771	C[457]= 0,000073433	C[458]= 0,000070095	C[459]= 0,000066280
C[460]= 0,000062943	C[461]= 0,000059605	C[462]= 0,000055790	C[463]= 0,000052929
C[464]= 0,000049591	C[465]= 0,000046253	C[466]= 0,000043392	C[467]= 0,000040531
C[468]= 0,000037670	C[469]= 0,000034809	C[470]= 0,000032425	C[471]= 0,000030041
C[472]= 0,000027657	C[473]= 0,000025272	C[474]= 0,000023365	C[475]= 0,000021458
C[476]= 0,000019550	C[477]= 0,000018120	C[478]= 0,000016689	C[479]= 0,000014782
C[480]= 0,000013828	C[481]= 0,000012398	C[482]= 0,000011444	C[483]= 0,000010014
C[484]= 0,000009060	C[485]= 0,000008106	C[486]= 0,000007629	C[487]= 0,000006676
C[488]= 0,000006199	C[489]= 0,000005245	C[490]= 0,000004768	C[491]= 0,000004292
C[492]= 0,000003815	C[493]= 0,000003338	C[494]= 0,000003338	C[495]= 0,000002861
C[496]= 0,000002384	C[497]= 0,000002384	C[498]= 0,000001907	C[499]= 0,000001907
C[500]= 0,000001431	C[501]= 0,000001431	C[502]= 0,000000954	C[503]= 0,000000954
C[504]= 0,000000954	C[505]= 0,000000954	C[506]= 0,000000477	C[507]= 0,000000477
C[508]= 0,000000477	C[509]= 0,000000477	C[510]= 0,000000477	C[511]= 0,000000477

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**C.1.4 Psychoacoustic models**

Two examples of psychoacoustic models are presented in annex D, "Psychoacoustic models".

**C.1.5 Encoding****C.1.5.1 Layer I encoding****C.1.5.1.1 Introduction**

This clause describes a possible Layer I encoding method. The description is made with reference to figure C.5, "Layer I, II Encoder Flow Chart".

**C.1.5.1.2 Psychoacoustic model**

The calculation of the psychoacoustic parameters can be done either with Psychoacoustic Model 1 described in clause D.1, or with Psychoacoustic Model 2 as described in D.2. The FFT shiftlength equals 384 samples. Either model provides the signal-to-mask ratio for every subband.

**C.1.5.1.3 Analysis subband filtering**

The subband analysis is described in the clause C.1.3, "Analysis subband filter".

**C.1.5.1.4 Scalefactor calculation**

The calculation of the scalefactor for each subband is performed every 12 subband samples. The maximum of the absolute value of these 12 samples is determined. The lowest value in table B.1, "Layer I, II Scalefactors", which is larger than this maximum is used as the scalefactor.

**C.1.5.1.5 Coding of scalefactors**

The index in the table B.1, "Layer I, II Scalefactors" is represented by 6 bits, MSB first. The scalefactor is transmitted only if a non-zero number of bits has been allocated to the subband.

**C.1.5.1.6 Bit allocation**

Before adjustment to a fixed bitrate, the number of bits that are available for coding the samples and the scalefactors must be determined. This number can be obtained by subtracting from the total number of bits available "cb", the number of bits needed for the header "bhdr" (32 bits), the CRC checkword "bcrc" if used (16 bits), the bit allocation "bbal", and the number of bits required for ancillary data "banc":

$$adb = cb - (bhdr + bcrc + bbal + banc)$$

The resulting number of bits can be used to code the subband samples and the scalefactors. The principle used in the allocation procedure is minimization of the total noise-to-mask ratio over the frame with the constraint that the number of bits used does not exceed the number of bits available for that frame. The possible number of bits allocated to one sample can be found in the table in 2.4.2.5 of the main part of the audio standard (Audio data, Layer I); the range is 0...15 bits, excluding an allocation of 1 bit.

The allocation procedure is an iterative procedure, where in each iteration step the number of levels of the subband samples of greatest benefit is increased.

First the mask-to-noise ratio "MNR" for each subband is calculated by subtracting from the signal-to-noise-ratio "SNR" the signal-to-mask-ratio "SMR":

$$MNR = SNR - SMR$$

The signal-to-noise-ratio can be found in the table C.2, "Layer I Signal-to-Noise Ratio". The signal-to-mask-ratio is the output of the psychoacoustic model.

Then zero bits are allocated to the samples and the scalefactors. The number of bits for the samples "bspl" and the number of bits for the scalefactors "bscf" are set to zero. Next an iterative procedure is started. Each iteration loop contains the following steps :

- Determination of the minimal MNR of all subbands.
- The accuracy of the quantization of the subband with the minimal MNR is increased by using the next higher number of bits.
- The new MNR of this subband is calculated.
- bspl is updated according to the additional number of bits required. If a non-zero number of bits is assigned to a subband for the first time, bscf has to be incremented by 6 bits. Then adb is calculated again using the formula:  

$$adb = cb - (bhdr + bcrs + bbal + bscf + bspl + banc)$$

The iterative procedure is repeated as long as adb is not less than any possible increase of bspl and bscf within one loop.

#### C.1.5.1.7 Quantization and encoding of subband samples

A linear quantizer with a symmetric zero representation is used to quantize the subband samples. This representation prevents small value changes around zero from quantizing to different levels. Each of the subband samples is normalized by dividing its value by the scalefactor to obtain X, and quantized using the following formula :

- Calculate  $AX+B$
- Take the N most significant bits.
- Invert the MSB.

A and B can be found in table C.3, "Layer I Quantization Coefficients". N represents the necessary number of bits to encode the number of steps. The inversion of the most significant bit (MSB) is done in order to avoid the all '1' representation of the code, because the all '1' code is used for the synchronization word.

#### C.1.5.1.8 Coding of bit allocation

The 4-bit code for the allocation is given in 2.4.2.5, "Audio data Layer I", of the main part of the audio standard.

#### C.1.5.1.9 Ancillary data

The Audio standard provides a number of bits for the inclusion and transmission of variable length ancillary data with the audio bitstream. The ancillary data will reduce the number of bits available for audio, which may result in a degradation of audio quality.

The presence of a bit pattern in the ancillary data matching the syncword may hamper synchronization. This problem is more likely to occur when the free format is used.

#### C.1.5.1.10 Formatting

The encoded subband information is transferred in frames (See also 2.4.1.2, 2.4.1.3, 2.4.1.5 and 2.4.1.8). The number of slots in a frame varies with the sample frequency (Fs) and bitrate. Each frame contains information on 384 samples of the original input signal, so the frame rate is  $F_s/384$ .

$F_s$ (kHz)	Frame size (ms)
48	8
44,1	8,7074...
32	12

A frame may carry audio information from one or two channels.

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The length of a slot in Layer I is 32 bits. The number of slots in a frame can be computed by this formula:

$$\text{Number of slots/frame (N)} = \frac{\text{bitrate}}{F_s} * 12$$

If this does not give an integer number the result is truncated and 'padding' is required. This means that the number of slots may vary between N and N + 1.

An overview of the Layer I format is given in figure C.2:

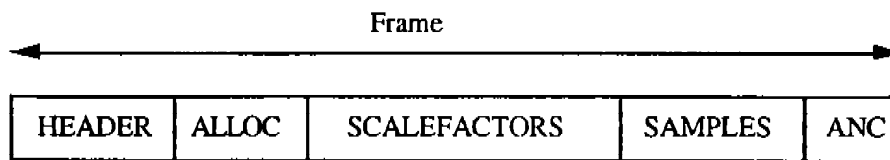


Figure C.2 -- Layer I Format

Table C.2 -- Layer I Signal-to-Noise Ratios

No. of steps	SNR (dB)
0	0,00
3	7,00
7	16,00
15	25,28
31	31,59
63	37,75
127	43,84
255	49,89
511	55,93
1 023	61,96
2 047	67,98
4 095	74,01
8 191	80,03
16 383	86,05
32 767	92,01

Table -- C.3 Layer I Quantization Coefficients

No. of steps	A	B
3	0,750000000	-0,250000000
7	0,875000000	-0,125000000
15	0,937500000	-0,062500000
31	0,968750000	-0,031250000
63	0,984375000	-0,015625000
127	0,992187500	-0,007812500
255	0,996093750	-0,003906250
511	0,998046875	-0,001953125
1 023	0,999023438	-0,000976563
2 047	0,999511719	-0,000488281
4 095	0,999755859	-0,000244141
8 191	0,999877930	-0,000122070
16 383	0,999938965	-0,000061035
32 767	0,999969482	-0,000030518

**C.1.5.2 Layer II encoding****C.1.5.2.1 Introduction**

This clause describes a possible Layer II encoding method. The description is made according to figure C.5, "Layer I, II encoder flow chart".

**C.1.5.2.2 Psychoacoustic model**

The calculation of the psychoacoustic parameters can be done either with Psychoacoustic Model 1 described in clause D.1. or with Psychoacoustic Model 2 described in clause D.2. If Psychoacoustic Model 1 is used to calculate the psychoacoustic parameters, the FFT shiftlength is 1152 samples. If Psychoacoustic Model 2 is used, the calculation is performed twice with a shiftlength of 576 samples and the largest of each pair of signal to mask ratios is used. Either model provides the signal-to-mask ratio for every subband.

**C.1.5.2.3 Analysis subband filter**

The analysis subband filter is described in clause C.1.3, "Analysis subband filter".

**C.1.5.2.4 Scalefactor calculation**

The calculation of the scalefactor for each subband is performed every 12 subband samples. The maximum of the absolute value of these 12 samples is determined. The lowest value in table B.1, "Layer I, II Scalefactors", which is larger than this maximum is used as the scalefactor.

**C.1.5.2.5 Coding of scalefactors**

A frame corresponds to 36 subband samples and therefore contains three scalefactors per subband. Define 'scf' as the index in table B.1, "Layer I, II Scalefactors". First, the two differences  $dscf_1$  and  $dscf_2$  of the successive scalefactor indices  $scf_1$ ,  $scf_2$  and  $scf_3$  are calculated:

$$\begin{aligned} dscf_1 &= scf_1 - scf_2 \\ dscf_2 &= scf_2 - scf_3 \end{aligned}$$

The class of each of the differences is determined as follows:

class.	dscf
1	$dscf \leq -3$
2	$-3 < dscf < 0$
3	$dscf = 0$
4	$0 < dscf < 3$
5	$dscf \geq 3$

The pair of classes of differences indicate the entry point in table C.4, "Layer II Scalefactors Transmission Patterns". The column labelled "scalefactor used in encoder" gives the three scalefactors which are actually used. "1", "2" and "3" mean respectively the first, second and third scalefactor within a frame, "4" means the maximum of the three scalefactors. If, after this adjusting of scalefactors two or three are the same, not all scalefactors need to be transmitted for a certain subband within one frame. Only the scalefactors indicated in the "transmission pattern" column are transmitted. The information describing the number and the position of the scalefactors in each subband is called "scalefactor selection information".

**C.1.5.2.6 Coding of scalefactor selection information**

The "scalefactor selection information" (scfsi) is coded by a two bit word, which is also to be found in table C.4, "Layer II scalefactor transmission patterns". Only the scfsi for the subbands which will get a nonzero bit allocation are transmitted.

**C.1.5.2.7 Bit allocation**

Before adjustment to a fixed bitrate, the number of bits, "adb", that are available for coding the samples and the scalefactors must be determined. This number can be obtained by subtracting from the total number of